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EFFECTS OF INITIAL BODY SIZE AND DIETARY PROTEIN LEVELS ON PRODUCTIVE PERFORMANCE OF NILE TILAPIA(*Oreochromis niloticus*).

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ABSTRACT

Nile tilapia (*Oreohromis niloticus*) with different initial body sizes were divided into three size groups (mean initial size): small (1.5 g), medium: (9.0g) and large : (16.0 g) and reared for 112 days in glass aquaria. Under each size, the fish were divided into five groups and fed on five experimental diets containing 15 ,20,25,30 and 35% dietary crude protein levels. Ten fish were placed randomly in each of 30 glass aquaria (100 l water capacity/each) in order to study the effects of the initial body size and dietary protein levels on the growth performance and feed and nutrients utilization of tilapïa. Fish were hand fed twice daily, six days a week at rate of 4% of its body weight.

The results indicated that the absolute values of fish weight (g/fish) , fish gain and average daily gains were significantly (P<0.05) increased with increasing the initial body size from 1.5 to 9.0 and 16 g /fish, receptively. However, values of specific growth rate (SGR%) were significantly (P<0.05) decreased with increasing the initial body size. On the other hand, increasing dietary protein levels from 15 to 35% CP significantly (P<0.05) increased growth performance criteria.

Fish body composition at the end of the experiment showed a slight increase in carcass dry matter and crude protein contents with increasing the initial body size and dietary protein levels. However, values of carcass ether extract and ash were decreased. Energy contents (Kcal/100g) of fish carcass at the end of the experiment were similar in all treatments.

The results showed that values of feed conversion ratio (FCR) , protein utilization {expressed as protein efficiency ratio (PER) and protein productive value(PPV%)}and energy utilization (EU)were significantly (P<0.05) improved with increasing the initial fish body size . However, values of FCR and EU% were significantly (P<0.05) improved but PER and PPV% were decreased with increasing the dietary protein levels .

Finally, it could be concluded that small size fish was more efficient and achieved higher growth performance than large size fish. Increasing the dietary protein level from 15 to 35% CP increased the growth performance, however, feed utilization criteria were decreased.

INTRODUCTION

Farming of tilapia species has received considerable interest in Egypt over the past two decades. Production of tilapia increased from 8000 metric tonnes (t) in1985 to 177000 t. in 2002(Soltan, 2003) As fish farming increase, there will be greater emphasis on optimization of production through maximizing biomass yield with lowest possible input (Purdom,1974). And to achieve this, sufficient resources must be made available for all individuals. Size grading is used in the culture of many fish species in an attempt to improve growth and survival (Kamastra,1993).Size grading by separating small and large fish individuals from each other to avoid potentially negative effects of social interactions (Jobling,1995). Competition for food seems to be particularly important in governing growth(Jobling and Koskela,1996). Without competition from large fish, smaller individuals avoid the negative effects of dominance hierarchy and may achieve higher growth rates (Purdom, 1974).

Some studies have been attempted to determine the exact dietary protein requirements of tilapia to maximize growth (Cruz and Laudencia, 1977; Winfree and Stikney, 1981; Wang *et al* ., 1985 and Siddiqui *et al*, 1988). However, other studies have been directed towards selecting low-cost, readily available feed ingredients as protein sources for tilapia diets (Cruz and Laudencia, 1977; Jauncey,1982; Winfree and Stickney, 1981; Wang *et al*., 1985 and Shiau *et al*., 1987). The reason for the very wide range of the optimum protein levels in the above mentained studies were not clear. However, initial fish body size could be one of the expected factors.El-Dahhar, (1994) reported that with 30.2 and 26.6 % dietary protein, Nile tilapia fry and fingerlings will grow as well as with higher protein diets when the fish of the intital body size of 1.0 and 9.0 g were tested , respectively.

In spite of these studies, the picture is still not clear and our knowledge on the optimum dietary protein level for different initial body sizes of tilapia is a matter of debate up till now.Therefore the following experiment was designed to investigate the effects of varing initial body size on the performance of young tilapia that fed five different levels of dietary protein

MATERIALS AND METHODS

This study has been carried out in the Wet Lab. for Fish Nutrition, Department of Animal Production, Faculty of Agriculture (El Shatby), Alexandria University.Nile tilapia (*Oreochromis niloticus*) of three initial body sizes (1.54 , 8.65 and 15.66 g) were fed five dietary protein levels (15,20,25,30 and 35 %CP) for 112 day and reared in glass aquaria in order to study the effects of initial body sizes and dietary protein levels on its growth performance and feed utilization. Thirty glass aquaria(100 l water capacity /each) were used in the present experiment(two/each treatment). Ten fish were randomly placed in each aquarium(100x40x30 cm) supplemented with continuous areation and one third of its water was changed daily by freshly stocked dechlorinated tap water to flush out wastes. The experimental aquaria were maintained under a 12h light: 12h dark photo period regime through the study with fluorescent tube lights, which were arranged to ensure equal lighting throughout the laboratory aquaria.

Five isoenergetic diets of 436 Kcal gross energy/ 100g dry matter were prepared to contain 15,20,25,30 and 35% crude protein(CP %) as indicated in Table 1. Ingredients were ground (0.5-mm particle size),the mixture was subsequently mixed with vitamins, minerals and oil and then pelleted in a large mincer with 3-mm holes and dried at 70 °C for 48 hrs. The dried pellets were immediately stored at -20°C.

Table (1): Composition and chemical analysis of the experimental diets .

Item	Diet No*				
	1	2	3	4	5
Ingredients (%)					
Fish meal	5	10	15	20	25
Soybean meal	6	13	20	27	34
Wheat bran	10	10	10	10	10
Wheat meddling by-product	37	31	25	19	13
Yellow corn	37	31	25	19	13
Corn oil	3	3	3	3	3
Vitamin mixture**	1	1	1	1	1
Mineral mixture***	1	1	1	1	1
Chemical analysis (%)					
Dry matter (DM)	92.17	92.22	92.20	92.18	92.24
% on DM basis					
Crude protein (CP)	15.90	20.40	25.30	30.80	35.20
Ether extract (EE)	7.71	7.52	6.87	6.52	6.16
Crude fiber (CF)	3.19	3.32	2.81	2.25	2.00
Ash	7.64	7.84	9.53	10.92	12.30
NEF****	65.56	60.92	55.49	49.51	44.34
Gross energy(GE,kcal/100 g DM)	432	436	436	439	439
P/E (mg protein /kcal GE)	36.82	46.74	58.08	70.20	80.20

* Diets 1,2,3,4 and 5 contained 15, 20, 25, 30 and 35% dietary protein levels, respectively.

** Vitamin mix. (g/kg): Vit. A(0.012), Ergocalciferol (0.006) , Tocopherol (0.40), Menadione (0.04), Biotin (0.006), L-ascorbic acid (3.0), D-calcium pantothenate (0.28), Chloline chloride (8.0), Folic acid (0.015), Myo-inositol (4.0), Niacin (0.80), Pyridoxine HCl (0.04), Riboflavin (0.20), Thiamine HCl (0.06) BHT (0.30), Celufid (12.44).

*** Mineral mix. (g/kg): Ca $(H_2PO_4)_2H_2O$(0.40), Ca-lactate(1.0), Fe citrate (0.10), $MgSO_47H_2O$ (0.40), K_2HPO_4 (0.70), $NaH_2PO_4H_2O$ (0.25), $AlCl_36H_2O$ (0.02), $ZnSO_47H_2O$(0.126), $CuSO_45H_2O$(0.03), $MnSO_4H_2O$(0.015), KI(0.02), $CaCl_26H_2O$(0.02).

**** NFE = Nitrogen free extract = 100-(CP+ EE+ CF+ ash).

Fish in each aquarium were hand fed twice daily at 9.0 am and 4.0 pm, six days a week, at a rate of 4% of body weight on a dry weight of feed basis for 112 days. Feed weights were adjusted weekly after the biomass in each aquarium was determined. The amount of feed given to each aquarium was determined at the end of the study. At the end of the experiment the final weight of fish in each aquarium was measured. Water in each aquarium was thermostatically controlled by using thermostatic heaters. Cole parmer, Oxygen meter (Model 5946-55) was used to determine the concentration of dissolved oxygen (DO_2) and temprature was measured in the water in each aquarium daily at 8.0 am. The average values were 6.6±0.2 ppm DO_2 and 28 ± 1.0 °C . Fish in each aquarium were killed and immediately frozen. Fish samples were pulverized, autoclaved and homogenized with ultra-tunax. The homogenized samples were oven dried at 60 to 80 °C.

The chemical analyses of the experimental diets and fish carcass were done according to the methods of A.O.A.C.(1984), while nitrogen free extract (NFE) was calculated by difference. The fish samples at the beginning and at the end of the experiment were separately blended in a mixer and dried at 65 °C overnight and was applied to the chemical analysis previously mentioned.

Gross energy of the experimental diets and fish carcass were calculated from the chemical composition using the factors 5.64,9.4,4.0 and

4.0 (Kcal GE/g DM) for protein, fat, fiber and carbohydrate, respectively (Jobiling, 1983).
The initial weight, final weight, gain,average daily gain , specific growth rate, feed intake, feed convertion ratio, protein efficiency ratio, protein productive value, energy utilization, dry matter, crude protein, ether extract, ash and energy content were subjected to analysis of variance using the software pckage (SPSS10) program.

RESULTS

Results in Table (1) show the composition and chemical analysis (%) of the five tested experimental diets containing different dietary protein levels(15.90, 20.40, 25.30 , 30.80 and 35.20 CP%). The experimental diets were isocaloric (432-439 Kcal/100g DM), and differ in protein /energy ratios which ranged between 36.82 and 80.20 mg protein /Kcal GE.

The effects of initial body size and dietary protein levels on growth performance criteria of Nile tilapia are shown in Table 2.

Table (2): Effect of initial body size and different dietary protein levels on growth performance of Nile tilapia (*Oreochromis niloticus*).

Initial body size (g/fish)	Diet No.	Body weight (g/fish)		Weight gain, (g/fish)		Specific growth rate, %/day (SGR)
		Initial	Final	Total	Daily gain (g/fish)	
1.5	1	1.53^{c}	21.67	20.14	0.18	2.57
	2	1.55^{c}	28.50	26.95	0.24	2.60
	3	1.54^{c}	33.67	32.13	0.29	2.75
	4	1.56^{c}	38.73	37.17	0.33	2.87
	5	1.52^{c}	45.80	44.28	0.40	3.04
9	1	8.66^{b}	45.64	36.98	0.33	1.48
	2	8.60^{b}	51.75	43.15	0.39	1.60
	3	8.71^{b}	56.36	47.65	0.43	1.67
	4	8.65^{b}	66.64	57.99	0.52	1.82
	5	8.63^{b}	79.60	70.97	0.63	1.98
16	1	15.70^{a}	64.21	48.51	0.43	1.26
	2	15.60^{a}	68.44	52.84	.47	1.32
	3	15.63^{a}	77.29	61.66	0.55	1.43
	4	15.65^{a}	92.37	76.72	0.68	1.58
	5	15.71^{a}	104.45	88.74	0.78	1.69
Fish size						
1.5		1.54^{c}	33.67^{c}	32.13^{c}	0.29^{c}	2.73^{a}
9		8.65^{b}	59.99^{b}	51.35^{b}	0.46^{b}	1.71^{b}
16		15.66^{a}	81.35^{a}	65.69^{a}	0.59^{a}	1.46^{c}
Diets						
1		8.63^{a}	43.84^{e}	35.21^{e}	0.31^{e}	1.77^{e}
2		8.58^{a}	49.56^{d}	40.98^{d}	0.37^{d}	1.84^{d}
3		8.63^{a}	55.77^{c}	47.15^{c}	0.42^{c}	1.95^{c}
4		8.62^{a}	65.91^{b}	57.29^{b}	0.51^{b}	2.09^{b}
5		8.62^{a}	76.61^{a}	68.00^{a}	0.60^{a}	2.24^{a}

-Diets 1,2,3,4 and 5 contained 15,20,25,30 and 35% crude protein respectively.
-specific growth rate (SGR)% per day : 100 (Ln w_2-Ln w_1)/t, where: Ln is the natural logarithm , w_2 is final weight, w_1 is the initial weight, t is the experimental period
-Means with different superscript in the same column /each item /each size or among means are significantly (P<0.05) different.

Growth performance expressed as final weight (W_2), gain (G) and aveage daily gain (ADG) were significantly ($P<0.05$) increased with increasing the initial fish body size(W_1) and the dietary protein levels. However, values of the specific growth rate (SGR%) were significantly ($P<0.05$) decreased with increasing W_1. Increasing the dietary protein levels linearly increased growth performance criteria among each size(Fig.1).

Results in Table (3) show the effects of initial fish body size (W_1) and dietary protein levels on carcass chemical composition of the tested fish at the end of the experiment. The results showed that fish carcass DM%, CP% and energy content were significantly ($P<0.05$) increased with increasing W_1 and dietary CP%. However, the values of carcass ether extract(EE%) and ash were decreased.

Table (3): Effect of initial body size* and dietary protein levels on chemical composition of Nile tilapia (*Oreochromis niloticus*).**

Initial body size (g/fish)	Diet No.	Dry matter, (%)	On Dry matter basis,%			Energy content Kcal/100 g DM
			Crude protein (CP)	Ether extract (EE)	Ash	
1.5	1	24.14^{e}	58.89	23.41^{a}	17.78^{a}	555.12^{e}
	2	24.32^{d}	59.13^{d}	23.25^{b}	17.62^{b}	554.96^{d}
	3	24.71^{c}	60.27^{c}	22.68^{c}	17.05^{c}	555.99^{c}
	4	24.93^{b}	60.37^{b}	22.67^{d}	16.96^{c}	556.46^{b}
	5	25.00^{a}	60.97^{a}	22.35^{e}	16.68^{e}	556.81 a
9	1	24.51^{e}	60.11^{e} 6	23.25^{a}	16.64^{a}	558.50^{e}
	2	24.78^{d}	60.32^{d}	23.18^{b}	16.50^{b}	559.02^{d}
	3	24.92^{c}	60.91^{c}	23.00^{c}	16.25^{c}	560.65^{c}
	4	25.11^{b}	61.21^{b}	22.91^{d}	15.88^{d}	561.49^{b}
	5	25.17^{a}	61.68^{a}	22.72^{e}	15.60^{e}	562.35^{a}
16	1	24.81^{e}	60.10^{e}	23.22^{a}	16.08^{a}	561.54^{e}
	2	24.95^{d}	60.94^{d}	23.11^{b}	15.95^{b}	561.86^{d}
	3	25.12^{c}	61.32^{c}	22.90^{c}	15.78^{c}	562.02^{c}
	4	25.31^{b}	61.48^{b}	22.83^{d}	15.69^{d}	562.26^{b}
	5	25.55^{a}	61.91^{a}	22.61^{e}	15.48^{e}	562.61^{a}
Fish size						
1.5		24.62^{c}	59.91^{c}	24.87^{a}	17.22^{a}	554.39^{c}
9		24.89^{b}	60.85^{b}	23.01^{b}	16.17^{b}	560.40^{b}
16		25.15^{a}	61.15^{a}	22.93^{c}	15.79^{c}	562.06^{a}
Diets						
1		24.49^{e}	59.70^{e}	23.29^{a}	16.83^{a}	557.57^{e}
2		24.68^{d}	60.13^{d}	23.18^{b}	16.69^{b}	558.95^{d}
3		24.92^{b}	60.83^{c}	22.86^{c}	16.36^{c}	558.90^{c}
4		25.12^{b}	61.02^{b}	22.80^{d}	16.18^{d}	559.40^{b}
5		25.24^{a}	61.52^{a}	22.56^{e}	15.92^{e}	559.94^{a}

*** Carcass composition of the initial weight of the fish was 23.22± 0.09% DM, 58.15 ± 0.03 % CP, 22.40±0.04% EE, 19.45 ±0.03ash and 539.43 Kcal/100 g DM.**

****Diets 1,2,3,4and 5 containing 15 ,20 , 25 , 30 and 35% dietary protein levels , respectively.**

-Means with different superscript in the same column /each item /each size or among means are significantly (P<0.05) different.

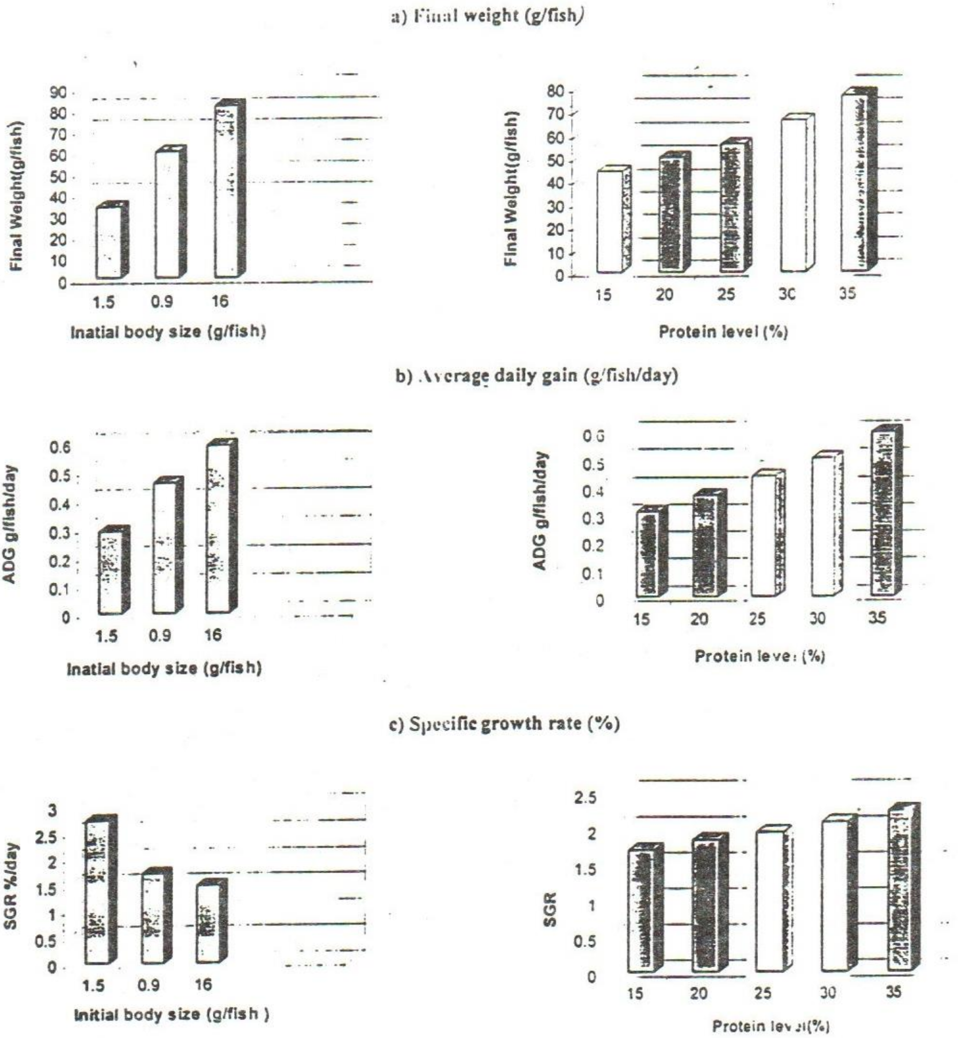

Fig. (1) Effect of initial body size and protein levels on growth performance on of Niletilapia, *O.niloticus* .
: a) final weight, b) average daily gain and c) specific growth rate (SGR%)

The effects of different initial body sizes and different dietary protein levels on feed and nutrients utilization of tilapia are shown in Table (4) and Fig.2. Feed consumption (g DM/fish) was significantly ($P<0.05$) increased while the values of feed conversion were significantly ($P<0.05$) improved with increasing W_1 and/or CP levels %. On the other hand, it was found that values of protein utilization expressed as protein effeciency ratio (PER) or protein productive value(PPV%) were significantly ($P<0.05$) increased with increasing of W_1 or decreasing dietary CP% levels. However,values of energy utilization(%)were significantly ($P<0.05$) increased with increasing W_1 or dietary CP% levels.

Table (4): Effect of different initial body sizes and nutrients utilization of Nile tilapia (*Oreochromis niloticus*).

Initial body size (g/fish)	Diet No.	Feed utilization		Protein utilization		Energy utilization EU(%)
		FI, (g/fish)	FCR	PER	PPV%	
1.5	1	69.89[e]	3.47[a]	1.81[a]	25.86[a]	8.72[e]
	2	85.16[d]	3.16[b]	1.55[b]	22.39[b]	9.81[d]
	3	93.91[c]	2.92[c]	1.35[c]	20.23[c]	10.55[c]
	4	99.62[b]	2.68[d]	1.21[d]	20.60[d]	13.05[b]
	5	107.16[a]	2.42[e]	1.17[e]	17.95[e]	12.91[a]
9	1	120.55[e]	3.26[a]	1.93[a]	28.79[a]	9.88[e]
	2	133.33[d]	2.09[b]	1.59[b]	24.04[b]	10.43[d]
	3	140.57[c]	2.99[c]	1.34[c]	20.70[c]	11.06[c]
	4	152.08[b]	2.62[d]	1.22[d]	19.31[d]	12.26[b]
	5	168.91[a]	2.38[e]	1.19[e]	19.27[e]	14.09[a]
16	1	153.79[e]	3.17[a]	1.98[a]	29.98[a]	10.33[e]
	2	158.52[d]	3.00[b]	1.63[b]	25.23[b]	10.33[e]
	3	171.23[c]	2.78[c]	1.39[c]	22.30[c]	11.59[c]
	4	180.30[b]	2.35[d]	1.38[c]	21.83[d]	14.05[b]
	5	186.60[a]	2.10[e]	1.35[d]	21.77[e]	15.88[a]
Fish size						
1.5		91.15[c]	2.93[a]	1.41[c]	20.40[c]	10.89[c]
9.0		143.09[b]	2.86[b]	1.45[b]	22.42[b]	11.54[b]
16		170.09[a]	2.68[c]	1.55[a]	24.22[a]	12.44[a]
Diets						
1		114.74[e]	3.30[a]	1.91[a]	28.21[a]	9.64[e]
2		125.67[d]	3.08[b]	1.59[b]	23.89[b]	10.19[d]
3		135.24[c]	2.88[c]	1.36[c]	21.08[c]	11.07[c]
4		144.00[b]	2.55[d]	1.27[d]	20.58[d]	13.12[b]
5		154.22[a]	2.30[e]	1.24[e]	19.66[e]	14.29[a]

Diets 1,2,3,4and 5 containing 15 ,20 , 25 , 30 and 35% dietary protein levels , respectively.
-FCR, feed conversion ratio = feed intake, g/total gain ,g.
-PER, protein efficiency ratio = total gain ,g/protein intake, g.
-PPV%, protein productive value =retained protein in fish body, g/protein intake, g x 100.
-EU%, energy utilization = retained energy in fish body, kcal/energy intake, kcal x 100
. -Means with different superscript in the same column /each item /each size or among means are significantly ($P<0.05$) different.

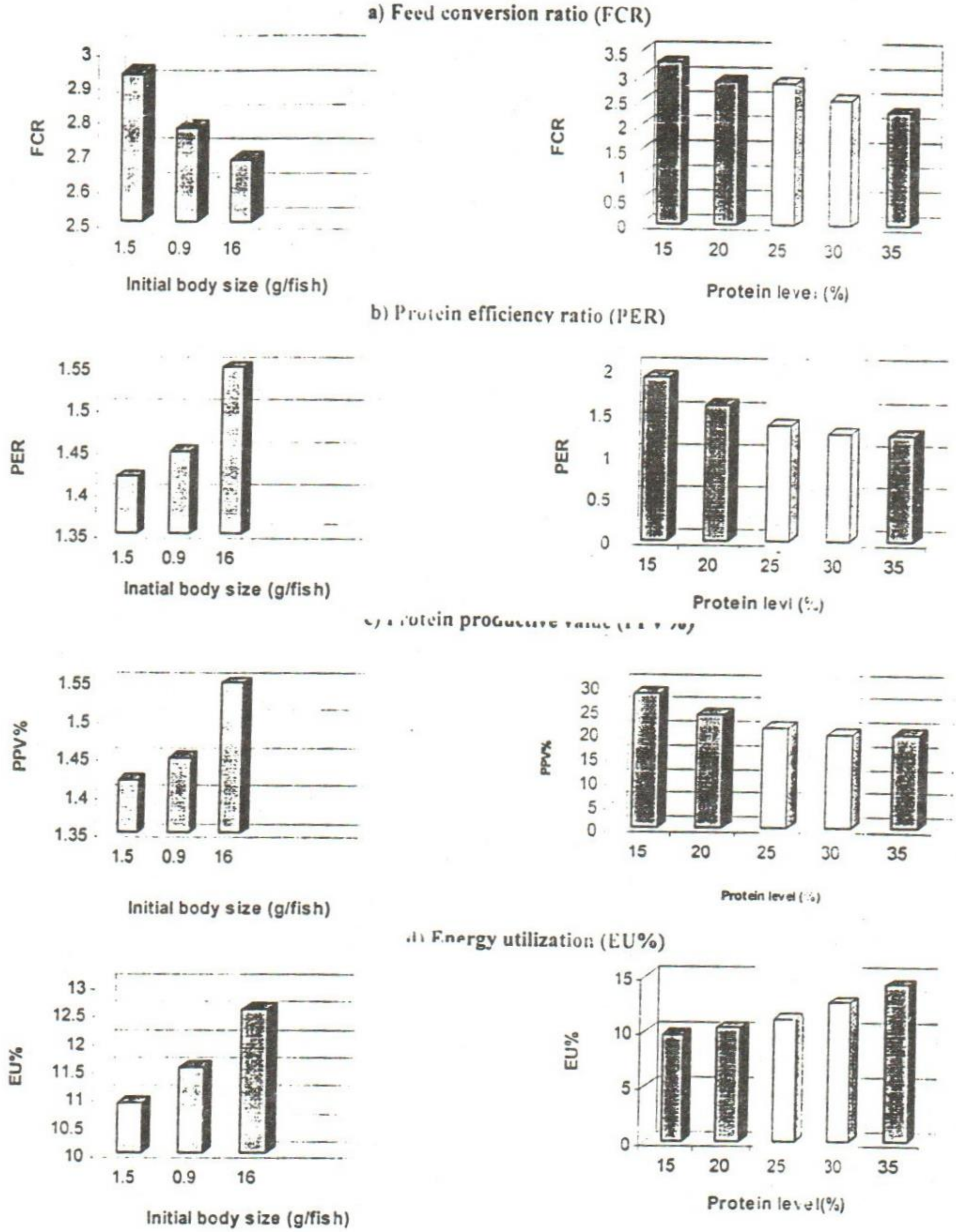

Fig. (2) Effect of initial body size and dietary protein level on feed and nutrient utilization of Nile tilapia ,*O.niloticus*

: a) feed conversion ratio, b) Protein efficiency ratio c) protein productive value and d) energy utilization

DISCUSSION

In the present experiment, the effects of the initial body size and dietary CP% levels on growth performance of tilapia were tested for 112 days in aquaria. The large tilapia with initial body size of 16g/fish showed the best growth with 35 and 30% dietary CP levels, respectively expressed as absolute final weight, gain and average daily gain, but was the lowest as SGR%. On the other hand, it was observed that tilapia with all initial body sizes gave the highest growth with the diet containing 35%, followed by 30%, 25%,20% and 15% dietary CP%, respectively. The differences were significant at 0.05% the (Table2). However, the results are in agreement with those of Siddiqui *et al.* (1988) worked on tilapia (*O. niloticus*) fry (0.84 g/fish). Hafedh(1999) studied the effect of dietary protein (25,30,35, 40 and 45% CP) on growth , survival ,food conversion ratio, protein efficiency ratio for four sizes (0.51, 45, 96 and 264g/fish) of tilapia, *O. niloticus*. The results showed a progressive increase in growth with increasing dietary protein. In fry (0.51g), significantly higher growth, survival and feed conversion were recorded for fish fed 40-45% CP rather than 25-35% CP diets. Similar trends for growth and feed conversion were also noted in 45g fish. For larger (96 and 264g) tilapia, significant differences in growth and feed conversion ratio were obtained and PER decreased with increasing weight of fish and both were found to be negatively correlated with dietary protein level.

The present results showed that increasing tilapia body size resulted in a significant ($P<0.05$) increase in carcas dry matter (DM%), crude protein (CP%) and energy content, however, ether extract and ash contents were decreased significantly ($P<0.05$). There is usually an increase in body fat and energy content with increasing body size in fish fed maximum rations (Cui *et al.*, 1996a and b). However, Xie *et al* (1997) reported that *O.niloticus* body size did not have significant effects on the content of crude fat and energy. The authors explained their findings on the basis that this is probably partly caused by decline in energy intake in larger tilapia as a result of sexual maturation , or due to the relative lipid content in the diet.

Values of feed intake (Table 4) were significantly increased with increasing the initial fish size or dietary protein levels up to 35% CP. Xie *et al.(*1997) reported that food consumption of *O.niloticus* fed to satiation twice a day with a diet containing 35.6 % CP were increased with body size.

On the other hand , the present results showed that the efficiency of feed utilization expressed as feed conversion ratio (FCR) was significantly ($P<0.05$) improved with increasing tilapia body size. Also values of protein (PER,PPV%) and energy utilization (EU%) were significantly ($P<0.05$) increased with increasing tilapia size. Feed conversion ratios (FCR) and energy utilization (EU%) in the present experiment were improved but PER and PPV% decreased by increasing dietary protein levels.

The best values of feed utilization (FCR) and energy utilization (EU%) were obtained with feeding all tested groups on the diet containing 35% CP. These findings are in agreement with the results reported by De Silva and Preera (1985) and Siddiqui *et al.*(1988). Jauncy (1982) found that FCR values decreasing with increasing dietary protein levels form 8 to 56%

for *O. mossambicus* fry. Values of protein utilization (PER and PPV%, Table 4 and Fig. 2) were significantly (P<0.05) decreased with increasing the dietary protein levels up to 35%CP. A similar trend was observed in all size groups of the tested tilapia.These results were as found in *Cyprinus carpio*(Ogino and Saito,1970), *Tilapia zilli* (Mazid *et al.*,1979) and *O. mossambicus* (Juancy, 1982).

The results of the present study indicated that growth performance, feed and energy utilization values were increased with increasing the dietary protein levels up to 35% CP for *O. niloticus*. However , values of protein utilization (PER, PPV%) were decreased.On the other hand , results of growth rate were higher in small size fish than the medium or large tested *O. niloticus*. However, feed and nutrient utilization values were significantly (P<0.05) higher for the large size than the small tested fish.

The present results are similar to those obtained by Santiago *et al.* (1982), who recommended 35% dietary protein content for fry. Cruz and Laudencia (1977) reported 35-40% protein as the optimum. Silva et al (1991) studied the interaction of varying dietary protein and lipid levels in young red tilapia. The authors concluded that all the three tested protein levels (15%, 20% and 30% CP) with 18% lipid resulted in the best growth for fish.

Finally it could be concluded that the growth performance of low initial body size tilapia (*O. niloticus*) expressed as SGR% was significantly (P<0.05) higher than medium or large sizes fish, respectively. On the other hand, increasing the dietary protein levels up to 35%CP improved growth performance of fish from different sizes.

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تأثير الوزن المبدئى ومستويات البروتين على الكفاءات الإنتاجية لأسماك البلطى النيلى

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وزعت أسماك البلطى النيلى بأوزان أولية مختلفة (١,٥ و٩ و ١٦ جرام / سمكة) فى ثلاث مجاميع وداخل كل مجموعة غذيت الأسماك على خمسة مستويات مختلفة من البروتين (١٥و ٢٠ و ٢٥و ٣٠ و٣٥ %) فى أحواض زجاجية لمدة ١١٢ يوما. وتم استخدام ٣٠ حوض زجاجى (بحجم مائي ١٠٠ لتر /حوض)، وتم وضع عشرة سمكات فى كل حوض (٢ حوض / معاملة). وغذيت الأسماك على العلائق الخمسة بمعدل مرتين فى اليوم يدويا وبمعدل تغذية ٤ % من الوزن الطازج للأسماك يوميا.وتشير النتائج إلى أن قيم الزيادة فى الوزن ومعدل الزيادة فىالوزن اليومى تزداد بزيادة حجم الأسماك من ١,٥ الى ٩ الى ١٦ جرام / سمكة على التوالى، ولكن قيم معدل النمو النوعى تقل .وفى الجانب الآخر نجد انه بزيادة مستويات البروتين فى العلائق من ١٥ : ٣٥ % بروتين تزداد معايير النمو . محتوى جسم الأسماك من المادة الجافة والبروتين يزداد بزيادة حجم الأسماك من١,٥ الى ١٦ جرام / سمكة وبزيادة مستويات البروتين فى العلائق من ١٥ : ٣٥ % بروتين على التوالى ، ولكن محتوى جسم الأسماك من الدهون والرماد يقل .محتوى جسم الأسماك من الطاقة كان متشابه فى كل المعاملات .وتشير النتائج أيضا إلى ان كفاءة التحويل الغذائى ، وكفاءة الاستفادة من البروتين والقيمة المنتجة للبروتين والاستفادة من الطاقة قد تحسنت معنويا بزيادة وزن الأسماك الأولى من١,٥ الى ١٦ جرام / سمكة، كما تحسنت قيم التحويل الغذائى والاستفادة من الطاقة لكن انخفضت الاستفادة من البروتين معنويا بزيادة مستويات البروتين فى العليقة .